ON THE PSYCHOLOGY AND PHYSIOLOGY OF READING. II.[1]

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In reading, then, at the ordinary distance,[2] say twelve to sixteen inches, the eye gets its data by a process of photographing successive sections of each line, the photographs overlapping constantly, and being taken at quite irregular distances. The conditions determining the points to be fixated have not been worked out. Introspection gives some suggestions about it which would be easy to write here, but which I believe to be entirely untrustworthy and perhaps misleading.

In reading lines of this length, from three to six fixations are made, usually four or five. But one line is read at a time.[3] In my experiments, about 80% of the line was traversed by the eye, the indentation being greater at the right. There were few retraceals, averaging about one in seven lines.

The forward movements seemed to occupy a little over 40σ, somewhat irrespective of the arc traversed, within certain limits. The return sweep was usually without interruption, and occupied from 50σ to 60σ.

The pauses occupied a variable time, averaging somewhere about 190σ. In fast reading the speed seemed to be gained by lessening the number and duration of the pauses.

It may be interesting to note the average number of words read per fixation. I append results of some representative readings of passages containing from nine to thirty lines each. The data were obtained by experiments with the direct attachment apparatus.

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[1] Continuation of paper published in this *Journal*, July, 1900.

[2] It seems surprising that no study should have been made of the optimum reading distance. Writers here and there advise this or that distance, but the advice seems to rest upon tradition, or upon observation of normal practice, rather than upon any experimental study.

[3] This has been so in every case, I think, which I have tested. The subjects were usually directed to "read for the thought by their own method." Of course, there is a "skipping and skimming" process with which we should all be familiar, in which both lines and thoughts are omitted.

ARTICLE.	LINE-LENGTH.	DISTANCE.	WORDS PER FIXATION.
Cosmopolitan Magazine,	121 mm.	33 cm.	1.83
"	121 "	33 "	1.50
American Journal (10 pt.),	98 "	35.5 "	1.96
" (8 pt.),	98 "	35.5 "	1.91
" (10 pt.),	98 "	33.0 "	1.70
Cosmopolitan Magazine,	60.5 "	33 "	3.63
"	43 "	33 "	2.60
"	37 "	33 "	2.44
"	30 "	35.5 "	1.94
"	25 "	33 "	1.58
"	25 "	33 "	2.16
"	21 "	33 "	2.17
"	21 "	35.5 "	3.33

It will be seen that with the short lines more words are read per fixation, though there is much variation, and little regularity of correlation shown between line length and words per fixation. Such variability is to be expected with the very short line lengths, when we consider how unusual they are, and how apt the eye would be to revert to old habits of moving a certain number of times each second, or for each phrase, or couple of words. In the shorter line-length, many of the movements were evidently from habit and not from necessity; as, *e. g.*, the eye would remain fixated while three or four lines were read, then shift a little and repeat, then zigzag, irregularly perhaps, For the reading of one of the 21 mm. passages above, I entered the following note: "In only three cases is a back and forward movement noticeable. Thirteen appreciably different fixations occurred. One fixation lasted two and one-half seconds, while the reading of whole passage (21 lines) occupied but about six seconds." With lines 25 mm. long, several lines would be read without shifting the eye. Toward the last of a 30 mm. passage the side to side movement was almost nil.

In all cases, with whatever line length, the eye moves oftener than would be necessary to get the printed matter within the range of clear vision. Thus, in my exposure experiments to determine extent of reading field, I read correctly, at first exposure of 15σ duration, one-third of such lines as these of this *Journal* article, on an average of several hundred trials; and this without help of context. Very nearly the half of such lines was read (seen clearly, as guessing was not allowed) from time to time, often enough to make me certain that my eye was capable of dealing with that extent of printed matter, when conditions of printing, arrangement of subject-matter, etc., were favorable. But with this possibility of three and a third to five words of average length per fixation, I actually read, as shown in the tests, about 1.9[1] words per fixation, photo-

[1] The average would be a little more than two words per fixation, if retraceals, breaks in return movement, etc., were excluded, as would

graphing the line at four or five points, even six sometimes. The reason for this can be discussed best when we know just what points are fixated and what effects various arrangements of printed matter may have upon the size of fixation sections.

Rate of Reading.

The reading rate varies greatly with the individual and with the subject matter. G. J. Romanes[1] found readers who read four times as fast as others of apparently equal intelligence and culture. Dr. Quantz[2] studied the matter extensively. He found as great individual differences as are given by Romanes, and states that the fast readers retain more of what they read than the slow ones.

I reget very much that Dr. Quantz has not carefully stated his method of determining the rate of reading. The rate is peculiarly apt to be affected by the conditions under which the test is made. Subjects mean such different things by "reading" a passage. I believe they usually have a tolerably constant rate for a given class of matter, about which they fluctuate according to circumstances. But it is difficult for either reader or experimenter to know whether this standard is being used in any given test. Again, it has not been shown that the fast readers for one class of matter may not be the slow readers for another. The possible speed always, and the actual speed in my own case at least, varies very much with the reader's apperception for the subject matter read.

The studies made thus far on the rate of reading, so far as I have been able to discover, give us no assurance that these sources of error have been eliminated; and knowing the difficulty of making the tests, especially with untrained subjects who so readily misconceive directions given them, I am convinced that we yet need (1) a thorough study of individual differences in rate based upon a *number* of tests taken at different times upon the same kind of reading matter, and repeated for diverse kinds of reading-matter; taking into account the subject's apperceptive relation to each class of matter; (2) a full and careful statement of the methods used in determining rate, if the results are to have anything of final scientific value.

I arranged a series of experiments, having for one of its objects to throw some light upon the matter of rate in reading,

be fairer for this comparison. Besides, the sections are irregular in size, and often three or four words, at least, are actually read at one fixation.

[1] "Mental Evolution in Animals," p. 136.

[2] Psychological Review, 1898.

and the possibility of increasing it; mainly hoping, however, to get insight into the subject's methods of reading, through the opportunities for direct observation and questioning which the experiments would afford. I do not offer the results as final determinations of rate for these subjects, though for the (uniform) class of matter used, I believe, they are of comparable validity with the results of rate-tests usually made thus far.

Eleven pages, each containing 405 words, were selected from an interesting novel which presented no peculiar difficulties to the reader; the pages having a somewhat similar arrangement of paragraphs, and being of as nearly equal interest and difficulty as possible.

These eleven printed pages were read by each subject, a page at one reading, the time being taken with a stop-watch. The reading was done at one sitting, in a quiet room, free from distraction, with the subject comfortable.

The first page was read silently, at normal speed and by the subject's "usual method," "the way you like to read"—the only other instruction being, substantially, that he read "continuously and for the thought." The second page was read exactly as the first. For the third page the subject was directed to think the words over in terms of sound, to auditize it, but at normal speed, and for the thought. The fourth page was motorized, at normal speed, but without lip-movement. The fifth was as the fourth, but *with* lip-movement. The sixth page was read aloud at the subject's most natural rate. The seventh, eighth, ninth, tenth and eleventh pages were duplications of the preceding as to method (except that but one page was read by "silent normal" method), but were read at maximum speed. In the readings aloud, the subjects were required to read loudly enough to be understood at a distance of fifteen feet at least.

The subjects were given preliminary practice for each page, and were not allowed to read until they understood clearly what was required. In all the readings, and especially in the "silent normal" readings, the greatest care was taken to have the subject fall into the mood in which he would do such readings in an easy-chair at home; and I believe that the results approximate somewhat nearly, at least, what would be obtained under such circumstances.

Below are the results for the twenty university students tested:

The table gives opportunity for various comparisons which may be of suggestive value to those who may work further upon these problems. It will be noticed that the individual differences found for "Silent, own method" reading are found to hold in lesser measure for readings by other methods, for

readings at maximum rate, and in the averages at the right from readings by all methods.

Subject.		Silent Own Method	Silent Own Method	Auditory	Motor. Lips Closed	Motor. Lip Movement	Aloud	Average
R	Normal Rate	8.8	10.8	10.5	10.9	9.8	4.4	9.20
	Max. Rate	13.5	——	10.8	12.0	8.7	6.4	10.28
B	Normal Rate	7.3	8.4	6.7	6.6	6.7	4.2	6.65
	Max. Rate	8.8	——	7.7	7.3	7.4	5.1	7.26
A	Normal Rate	7.0	7.7	7.0	5.4	4.1	3.8	5.83
	Max. Rate	10.7	——	10.6	9.5	6.7	5.5	8.60
M	Normal Rate	6.7	6.3	4.5	5.5	5.4	3.7	5.35
	Max. Rate	9.3	——	5.9	7.5	5.9	4.9	6.70
Q	Normal Rate	6.7	6.1	4.9	5.5	5.7	3.5	5.40
	Max. Rate	9.2	——	6.1	6.1	6.0	3.9	6.26
N	Normal Rate	6.6	7.3	7.9	7.9	6.6	4.7	6.83
	Max. Rate	8.8	——	9.6	10.6	8.7	5.5	8.64
E	Normal Rate	6.6	6.7	6.0	5.1	5.3	4.6	5.72
	Max. Rate	8.1	——	5.3	6.4	5.6	4.9	6.06
L	Normal Rate	6.1	6.9	5.1	6.7	5.3	3.5	5.60
	Max. Rate	12.4	——	7.7	7.3	4.8	5.1	7.46
C	Normal Rate	6.0	6.3	5.4	5.1	5.0	3.3	5.18
	Max. Rate	8.0	——	8.2	7.7	6.3	4.9	7.02
G	Normal Rate	5.5	5.6	4.9	4.4	4.6	3.7	4.78
	Max. Rate	7.0	——	5.6	7.2	6.0	4.7	6.10
S	Normal Rate	5.3	5.1	4.6	4.5	4.4	3.1	4.50
	Max. Rate	12.4	——	6.0	6.1	5.5	3.3	5.55
O	Normal Rate	5.0	6.3	5.0	5.0	4.2	3.8	4.88
	Max. Rate	7.1	——	6.3	6.4	6.0	5.5	6.26
H	Normal Rate	4.5	5.7	5.5	5.7	5.1	3.7	5.03
	Max. Rate	7.6	——	6.2	7.1	5.8	5.4	6.36
D	Normal Rate	4.1	4.7	4.1	4.2	4.3	3.0	4.07
	Max. Rate	6.5	——	5.3	6.3	5.4	4.2	5.54
J	Normal Rate	4.0	4.6	3.9	5.0	4.3	3.5	4.22
	Max. Rate	6.2	——	5.2	5.0	5.1	4.6	5.22
F	Normal Rate	3.9	4.7	3.8	4.6	4.4	3.2	4.10
	Max. Rate	5.9	——	5.4	5.6	4.7	3.2	4.96
T	Normal Rate	4.0	3.9	3.7	4.0	3.7	3.6	3.82
	Max. Rate	5.9	——	5.5	6.0	5.2	4.3	5.38
P	Normal Rate	3.5	5.4	4.4	4.5	3.5	3.4	4.12
	Max. Rate	9.7	——	5.6	5.6	4.8	3.9	5.92
K	Normal Rate	3.1	3.3	2.3	2.7	2.7	2.2	2.72
	Max. Rate	3.6	——	3.1	3.7	3.2	3.4	3.40
I	Normal Rate	2.4	2.5	2.1	2.5	2.6	2.2	2.38
	Max. Rate	3.5	——	3.0	3.6	3.3	2.9	3.26
Av.	Normal Rate.	5.35	5.91	5.12	5.29	4.88	3.55	
	M. V.	25.7%	23.1%	25.8%	22.5%	22.4%	13.1%	
	Max. Rate.	8.21	——	6.45	6.85	5.75	4.58	
	M. V.	25.5%	——	24.6%	21.2%	17.3%	16.5%	

NOTE.—The reader having slowest normal rate above had a segmental affection of the retina, which doubtless affected his speed.

The next slowest was a Japanese student who, however, had studied in American schools for a number of years. The numbers represent words read per second.

Throughout the experiments I was most interested in getting insight into the reader's method of reading. Lip-movement was usual with but two or three. One of these was one of my fastest readers, though for those unaccustomed to the method, the lip-movement evidently hindered speed.

By far the largest number seemed to be of the audito-motor type, emphasizing in various degrees the auditory or the motor elements. Readers often indicated their usual method clearly by the ease with which they comprehended and used it when assigned, and by again and again reading pages by the assigned method in almost the exact times used for the "own method" pages.

A strong rhythmic tendency was observed, and this aspect of reading merits a careful study. Readers fall into a natural rate, which gives almost exactly the same times for page after page. (I from time to time tested readers upon several additional pages, by the various methods, and especially by their accustomed method.) Habits of eye movement would seem to be an important factor in setting this pace. For example, the second page readings in the above table were from a page containing fewer lines than the first, though the lines were of equal length, and the only difference apparent was in the inter-spaces between words. The average times for reading the two pages were almost exactly proportional to the number of lines in each, for a somewhat larger number of subjects than are given in above table. I find by experimenting upon lines marked here and there by crosses for fixation without reading, that the eye readily falls into a very uniform rate of progress corresponding more or less closely to its usual rate in reading.

I was constantly impressed with the fact that reading may go on in motor images without any apparent traces of movement of lips or tongue. The movement seemed "up in the head" to many of the subjects.

The fact that we constantly hear our own utterances, has, acting with other factors, indissolubly welded together the auditory and motor elements. I am satisfied that these elements are never quite dissociated in normal reading; and that what subjects call auditizing, or motorizing, is a combination of the two, usually in more nearly equal proportions than their early introspective accounts would indicate.

A purely visual reader is certainly not an impossibility, theoretically at least. The direct linking of visual form to ideas, cutting out of circuit the somewhat cumbrous and doubtless fatiguing audito-motorizing mechanism, would seem to be a consummation to be wished for, from some points of view. When the proper preliminary investigation of the reading-process has been made, this will be one of the most important sub-

jects of pedagogical consideration. Practically, however, I have not found the purely visual type.

Perception of Reading-units.

My various experiments in the exposure of reading matter had for one of their main objects to give suggestions for a rational point of view from which to regard the whole matter of perception of reading-units. I am satisfied that such direct and continued contact with the processes as they go on under conditions which can be controlled is the best road to right theory in this difficult field.

I offer a tentative view of the matter, which may be generalized all too soon as I well know; but which, I am convinced, shows leadings toward the truth that will appear upon fuller investigation and more mature reflection.[1] Much is to be gained by regarding the perceiving of letters, words, and phrases as phenomena of association. When a letter or word is seen, the most habitual associate tends to appear in consciousness, in preference to less habitual ones; and the habitual associate will come so quickly as to fuse with the first if the association has been inveterate enough. Every letter, combination of letters, syllable, combination of syllables, word, combination of words, phrase, etc., has associates more or less habitual. Not only does the perception of the letter or word arouse the idea of its absent associated letter, word, etc., but, when the printed associate follows, its perception is facilitated in proportion to the extent of the habituation.

The child learns to read, either by associating the visual forms of letters with their names or with their sounds, or (in the word method) by associating the visual forms of word-

[1] My study of reading was interrupted in the spring of 1899, while yet in the observation stage, as I had first planned that it should extend over another year. I made a temporary summing up of the study at that time, but refrained from publishing in the hope that my prospective teaching duties would not prevent my making a more satisfactory conclusion of the study, or, at least, would permit my making a better and fuller presentation from the considerable amount of data already on hand.

I have not since found time or strength for further experimentation or reflection upon the subject; and regretfully publish it mainly as it stood in the earlier form.

Among the later and valuable literature which has appeared, the article by Bryan and Harter on "The Telegraphic Language" (Psych. Review, July, 1899), has been of especial interest to me. Starting from a quite different point of departure, the authors, it seems to me, reach much the same general conclusions as to the perception of reading-units as those to which I have been led in my study of the reading process. It has, of course, been encouraging to find this at least partial corroboration of my theory in the work of other and experienced investigators.

wholes with word-sounds and meanings. The association between the optical form of the letter and its *name* is not strengthened by later reading, and disappears, comparatively, in favor of the association with the letter's *sound*. This is clearly shown in my earlier experiments,[1] and in the still earlier ones of Prof. Cattell, in which the naming of isolated letters required more time than the speaking of short words.

Whether or not the association of the letter's visual appearance with its sound is arbitrarily memorized by the child in learning to read, it comes just as truly and certainly as he practices reading. A pupil taught to read by the word method first associates the optical form of the word as a whole with the sound of the word without linking parts of this sound with particular parts of the optical form, *i. e.*, with letters; and so his reading may go on for awhile. But gradually, even if he has never been taught that the optical form is composed of letter units, he will note the likeness of the crooked beginning of "star" with the crooked beginning of "slipper," *e. g.*, and will form an association of this crookedness with the hissing sound noticed as occurring in both words. The association of the optical form of the letter with its sound thus arises and soon becomes inveterate. Doubtless the appearance of letters at the beginning and end of words facilitates the linking of particular sounds with particular letter-forms; but it would come in any case; and I think it tolerably certain that, whatever the learning-method, the reader must and does come to feel the force, visual and auditory, of individual letters before he reads with much facility.

Now this optical crookedness and this hissing sound are comparatively seldom found alone, and occurring as they do with other optical shapes and other sounds tend to call up these other shapes and sounds when presented, and call up preferably and most quickly those with which they have been most often associated, other things being equal. If the visual "a" has most often had "x" appearing at its right, the sight of "a" will, other things being equal, tend to arouse the visual representation of "x," and the *sound* of "a" aroused by association with its optical form will tend to arouse the sound of "x" preferably. Of course the optical form and the sound "a" have been associated with many other letters, and the associative tracts representing these will also be aroused more or less. The associative tracts representing "z" and "q," letters seldom given with "a," will scarcely be aroused at all. Now if the word "ax" is suddenly exposed or appears in reading, the sounds corresponding to "a" and

[1] *American Journal of Psychology*, July, 1898.

"x" will at once come up as the most inveterate associates with these optical forms. But the optical form "a" will call up also its preferred associate "x;" and the sound of "a" will do the same for the sound of "x;" with a strengthening of the optical and auditory "a" by "x" also in proportion as "a" has more or less often preceded it as compared with a probably preferred "e" (in suffixes, etc.). Perhaps the association of optical forms from right to left may be as facile as that from left to right if we accept the apparent fact that the eye receives no data during its movement forward.

In a longer word such as slipper, "s" may subarouse the forms and sounds of various other letters than "l," though the association to "l" is facile as compared, for example, with that to "x." "l" has more or less frequently been associated with "i" following, and tends somewhat of itself to call it up as compared for instance with calling up "x." But the combination "sl" has far more frequently been given with "i" than has "l" when "l" has stood alone, and thus the effect of "s" preceding "l" is much to facilitate arousal of tracts representing "i." The combination "sli" tends to arouse comparatively few letters, such as "p." "t," "c," "m," "d," etc., and the trend of association is more and more constrained as less of the word remains.[1] The combination "nigh," for example, would almost invariably arouse "t," its almost invariable associate. In general, it only requires a direct application of fundamental principles of association to justify the statement, confirmed, however, by its agreement with the facts of observation, that letters have more or less preferred associates according to their habitual arrangements into words in a given language; and that letters presented in these preferred sequences mutually strengthen the visual and auditory perceptions of each other, and thus arouse the apperceptive complex representing the visual form of the word and its sound. When letters in nonsense arrangement are exposed, subjects often state that they have clearly seen many more than they can repeat to the experimenter. The letters as optical forms tended to call up their preferred letter-associates, but these rather hindered than helped the perception of the adjoining letters, and there could be no apperceptive knitting together into a complex which could be remembered.

The perceptions of the various parts of a letter shoot together into the perception of the whole letter, the part perceptions mutually assisting each other according as, from being often presented together, they have habits of interassociation; and knitting together into the complex perception-whole "a,"

[1] See James's Psychology, Vol. I, p. 365, *et al.*

"x," or what not. This first fusion seems to occur below the threshold of what we ordinarily term consciousness. The visual perception of the letter-unit is instantly supplemented by more or less of audito-motorization of its sound.[1] The perception of a word occurs similarly except that here auditory and motor (tactual), as well as visual elements enter into the fusion, in various proportions as the reader tends to the visual, auditory or motor type. The letter perception-units shoot together again in the perception of the whole word, the letter-perceptions mutually assisting or hindering each other according as the printed arrangement follows or violates habits of interassociation. There is the direct fusion of the *visual* letter perception-units; and the indirect but similar fusion of the auditory and motor elements that are linked with these visual units. This fusion into a word-unit is probably below the threshold of consciousness, for the most part, in most reading.

Word-perception is facilitated or hindered, it is true, by other factors than past co-presentation in vision, hearing, or speech. Certain auditory or motor elements blend easily with certain others, and the perception of these harmonious combinations will, of course, be comparatively facile though the combinations be new. The intrinsic difficulty of other combinations may overcome the tendency to facile perception incident to habitual interassociation. There are other factors which would have to be taken into account in an exhaustive treatment.

Now the knitting together into letter-wholes of data given from printed letter-parts seems to begin the instant the parts are presented, quite automatically, and may occur simultaneously at all points throughout as much as half the present *Journal* line-length, as it seemed in some of my experiments on extent of reading field. Subjects would state that they saw the letters clearly as letters; though they could not be remembered long enough for reproduction unless their transient life was reinforced by union into the more stable and permanent word-unit; and still better if this word-unit could be reinforced by union into some characteristic word-group; the higher complex units saving all their elements from falling into speedy oblivion.

Exactly similar are the readers' habits of association from word to word, and from phrase to phrase. The exposure of the word "A" beginning a sentence subarouses many of its past associates, preferably substantives or descriptive adjec-

[1] I allow myself here to use the term perception for processes which are ordinarily unconscious or subconscious. Perhaps, however, my meaning is as evident as I could make it with a more accurate use of terms.

tives. If "large" appears after it, the possibilities as to what may be the third word are narrowed to a manageable list, which are perhaps all subaroused. If "juicy" follows, the associations for the fourth word are still more limited, and often one or more of these is made so much more probable by the context or particular situation that the reader's apperception scarcely needs the appearance of the word "apple" to complete the phrase. On the other hand we can easily understand that the appearance on the page of a word violating this order of expectation would have its recognition hindered rather than helped by the existence of this apperceptive expectancy; and we are thus prepared to understand why the reading of nonsense matter takes about twice as much time as that of sense passages.

I shall defer further discussion of the perception of word-groups until I have given account of some experiments which I have made upon the associative and interpretative processes in reading.

Interpretative Processes in Reading.

Of the interpretative processes in reading there would seem to have been little experimental study thus far. The subject seems difficult to approach, yet of the greatest importance and interest. I arranged the following tentative experiments in the hope that, whatever the direct results, they might suggest a helpful method for further investigation.

Two passages of at least average interest and of only moderate difficulty were selected, one a description taken from a magazine article of how a spider spins its web, the other from the introduction to Percy's Reliques, describing the arrangement for the entertainment of Queen Elizabeth at Killingworth Castle. The passages contained some seventy-five words each. These were typewritten, and the lines cut out and pasted end to end on strips of cardboard, so as to make sense continuously throughout in a single long line.

From other typewritten copies the single words were cut and pasted on small pieces of cardboard. These cards were then shuffled, and were exposed, by means of a krypteon,[1] to the subject, one word at a time, in haphazard manner. Before the exposure, a ready signal was given, and the exposure lasted four seconds. The subject was seated comfortably in a quiet room, and was directed to look at the exposed word, and allow associations to play as they would in any direction.

The exposure of the sense matter was under similar general conditions. The first word of the passage was exposed, then

[1] Described on page 403, Sanford's Experimental Psychology.

the first two, then the first three, etc., a new word being given at each exposure along with the preceding context, the subject attending mainly to the new word in each case. In a few cases two or three words forming a phrase were exposed together in the sense passages, but usually but one new word was exposed.

Another sense passage of 130 words from a rather interesting magazine article on "Tribal Religions" was exposed, in phrases of two to five words, from beginning to end continuously, with context always in sight. To illustrate the character of the division into phrases, the following are some representative ones: "Political party," "Among their own countrymen," "Of the Pharisees," "Declared that," "It is true," etc.

Three subjects have been tested on the first series. The passage exposed by phrases has been given to one subject only. About a month was allowed to elapse between the exposure of the isolated words and of the context passages, which they formed.

The results show characteristic differences between the associations from isolated words and from words given in context for all subjects, though in most respects the subjects have very considerable individual differences.

The words given in isolation gave a much greater variety of association than did the context words, though the total amount of associated contents suggested by them is considerably less. When the isolated word appeared there was usually an indefinable recognition of the visual form of the word as familiar; and accompanying or very closely following this (probably the latter, though the subjects are not explicit), the word is usually "mentally pronounced." One subject whom I shall designate as "A" practically always had this mental pronunciation; another to be designated as "B" had it almost always, often with some associated word as "Atlantic cable," when "cable" was exposed, or "Can-can," when "can" was exposed. The third subject to be known as "C" quite frequently mentioned that the word was motorized, when first exposed, but more frequently did not mention this. This subject showed much more tendency to think in visual terms than did the others. The motorization of a word would seem to have often been present and disregarded, as was discovered sometimes by questioning. Usually, however, the subjects were not questioned at all, but dictated as fully and accurately as they could just what had been in consciousness during the four seconds, doing this immediately after the end of the exposure; the experimenter recording their account as nearly in their own words as practicable consistently with the necessary condensa-

tion. It may be mentioned that the subjects were all university men and accustomed to introspection. This subject "C" very frequently had associated phrases come up a little *after* the beginning of the exposure, and these were almost always mentally pronounced.

The subjects were generally unable to say after careful introspection whether this mental pronunciation meant motorizing, or auditizing, or a combination of the two. They inclined in general toward the latter view, emphasizing the motor or auditory elements according to circumstances.

After the visual recognition and mental pronunciation of the isolated word was apt to come a mental pronunciation of some phrase or other word in which it had often occurred to the subject: as "Sweet by-and-by" from "by," "Himself, herself, itself," from "himself," "Vertical writing" from "vertical." The word was rather especially apt to suggest some line of poetry which would often be but dimly suggested, leaving the subject with a vague and tantalizing feeling of something which he could not get. This occurred much more often with subject "B" than with the others. The vivid arousal of the *feelings* belonging to words and phrases which were thus but subconsciously aroused was a phenomenon often occurring with him. In general, words showed a tendency to call up groups with which they had been rhythmically connected. Words were often pronounced "interesting," "agreeable," "full of meaning," or the opposite of these, and occasionally these judgments seemed to refer to the sound or visual appearance of the words themselves; but more usually the feeling seemed to be traceable to some particular associations or uses of the word in past experience; and though this reference could not always be made, as was the case also with the suggested phrases from poetry, still it seems probable that the feelings were usually associatively mediated by words or situations which do not any longer appear above the threshold.

As has been said the associations from isolated words were of the most varied character. The word, "top," for instance, gave a visual picture of a hilltop, then the motorized phrase, "Top of hill," then another mental picture of a hill with disappearing base, then a mental picture of a flagstaff on the hilltop at home, then a visual picture of a top given to the subject as a present in his boyhood days, and memory of seeing it wound up and spun, with the memory of the singing noise which it made. Again the motorization of an exposed word would suggest another similar in sound, and the association would start from this. The word would sometimes be divided and associations taken from different parts; or the

word would be given different significations in different parts of the exposure time.

One of the most striking things brought out was the lack of association from connective and relational words, definitive adjectives, etc.; and the displeasure with which they came consequently to be regarded. They seldom aroused any ideas directly, and few associations of any kind except verbal ones, usually phrases of which they customarily form a part. Occasionally they gave evidence of setting the subject's thoughts in characteristic directions of expectancy; and doubtless the prepositions, especially, always had some very general influence in determining how the whole thought organism should face the coming related object. These vague expectancies were occasionally noticed by the subjects, particularly in the case of such words as "between," "into," etc. The whole feeling of the subjects toward these words and their inability to call up associations irresistibly suggested that the mind had no place for them as separate wholes, and that there was no normal way of thinking them except as more or less fused components of larger units; viz.: as parts of phrases, and perhaps sentences as they continually occur in reading.

Turning to the associations from words given in context, we find as their most distinguishing characteristic that they are far less variable. The mere statement that the word to be exposed is part of a reading passage limits the trend of association when no context has been given. The limitation extends further when the subject has caught the general topic discussed in the passage, and still further when the exposed word is given upon a verbal and ideational background formed by preceding context. In the case of the word "top," for example, after the mention of "web-weaving" the word "top" no longer suggests "top of hill," "flag-staff," "spinning tops," etc., but preferably the "top of a post or gateway," with "spider-situation" in mind, and a greater vividness of the suggested picture for its having already been partially aroused in expectation.

This difference in the trend of association is shown by all subjects, but much more by some than others; and it varies from time to time as the subject's greater or less interest made him more or less approximate the condition of normal reading.

The newly exposed word was usually mentally pronounced as before, and "fitted into the preceding," as was very often remarked by one subject; the new word contributing apparently toward a notion of sentence unity, to which each additional element added a needed part. Immediately following this there was in a majority of cases a filling out of the sentence or phrase so as to make sense with the preceding con-

text, and when this did not occur there was usually a "forward push," "forward tendency," "tendency to fill out," as it has been very frequently described by the subjects. All subjects have emphasized the strength and comparative constancy of this feeling, and mentioned it as perhaps the most striking thing to be observed in the experiment. It was not present in any considerable degree at the beginning of paragraphs, nor at the close of sentences and paragraphs. The "little words" (as the subjects came to call the words expressing relation, etc.), gave but little except this forward feeling and verbal associations. They seemed, as subject "A" remarked several times, to be but "verbal counters" in the sentence.

Subject "A" showed comparatively little tendency to visualize throughout the experiment. There was, however, visualizing of some of the main objects and scenes referred to in the passages read,—enough to form a vague background for the story, which seemed, however, in the main to be thought in verbal terms. Subjects "B" and "C," however, had more of the visual element, and the interpretative process with them seemed to be more or less independent and parallel with the verbal associative complex. In the story of the spider's weaving its web, for example, a visual picture of a spider was early formed, which was present throughout, though more or less modified to suit the different references to it as the story progressed. The spider was seen in a visual background that had different components fused into it in a kaleidoscopic fashion, as the story gave additional data; but no violent breaks were made. While this scene would pass out of the attention field sometimes as some substantive would call up scenes peculiar to itself, it constantly remained as a factor controlling the course of expectation and association.

This visualization was almost always static. The spider jnmping was visualized as the spider ready to jump or just alighted. The thought of motion, when mentioned at all, seemed to be one of tendency to movement in the subject's motor organism.

The agreement or disagreement of the exposed word with the trend of expectation produced by the preceding context was a matter of frequent remark by the subjects, and often of considerable feeling on their part. No matter whether or not the subject had consciously formulated his expectations, there was a feeling of rightness or wrongness about the sequences, which was expressed in judgments of fulfilled or disappointed expectation. That this disappointment or fulfillment of expectation was not caused merely by getting or failing to get the particular verbal form desired, irrespective of its intrinsic fitness, is evidenced by the frequent judgments that the given word

though different was "all right," "still better," etc. Sometimes the new word given really closed the sentence to the subject's expectation, and the author's appending some corollary caused displeasure.

It would be profitable, if I had time and space sufficient, to give a detailed account of the results of exposure by phrases of the article on "Tribal Religions." A few comments must suffice, though I hope to make more use of the data, and especially of the method of experimenting, at some later time.

In almost every case the phrase was first "read and motorized," as the subject put it. It would seem as though this meant a recognition of the visual form first with a closely following motorization; though just what the "read" meant was rather uncertain to both of us. The processes usually seemed simultaneous to the subject's introspection. (I might say the subject was a thoroughly trained observer). Following this there was almost always either a "fitting in" of the word-group with what preceded, or a "filling out" with some word or group of words; according (usually) as the exposed phrase made closer connections with the preceding or following context. The fitting in with the preceding would be expressed in such words as "joined with what came before;" "recognized that this was sense expected though not the words;" "felt the fulfillment of expectation though words were quite different from expected;" "Sense fell in with the expected sense;" "gave phrase its place in sentence as far as could;" "gave it its place as completion of sentence;" (these are from subject's dictation, paraphrased sometimes).

The filling out would not always be with definite words. It was often expressed as "tendency to complete," "tendency forward," "very strong tendency to fill out." Quite usually, however, definite words or phrases came to mind, completing what was given. The subject remarked on one occasion that this forward tendency was by all means the most prominent of the things to be observed introspectively. There was occasional dissatisfaction at the non-fulfillment of expectation.

The subject had shown comparatively little tendency to visualize in my previous experiments with him, and showed no more in this. He remarked on one occasion that throughout the experiment he was struck with the little amount of visualization as compared with the verbal association. On another occasion he remarked that the words served simply as "counters" till he got "the whole thing."

There was a vague general picturing of location of what was described, and some vague visualization of main scenes and characters. But for the most part by far the subject was concerned with words and their interassociations. There were in-

frequent tendencies to translate into other terms, as when "condemned" seemed to suggest a gesture of striking down with the arm. These translations were usually but incipient and rather intangible.

I feel the need of much more experimenting, and especially of much more time than I have had for reflection upon the associative and interpretative processes in reading, before attempting any final account of them. Provisionally and roughly, I should say that in reading there were two sets of processes, somewhat independent and paralleling each other: (1) a reading in terms of interassociated word and phrase units (themselves composed of interassociated sub-units), thought in a variously proportioned combination of visual, auditory, and motor elements; (2) a reading (or interpretation) in terms of direct representations of the realities with which the subject matter deals; a picturing in sense terms of what the words symbolize.

The relative prominence of the two processess varies greatly with the individual, and, of course, with the subject matter as well. The first is the constant process, is the major part of the performance for most readers; is the part which makes the heavy draft on the psychophysical machinery—is the fatiguing and delaying process. It is the *ding an sich* for the average reader.

The second process is a sort of dramatization in which the reader sees and hears and smells and tastes, and takes a part. Consciousness may almost desert the first process in its interest in the scenery of the second; yet this scenery is constantly being changed by the word-workers behind; and it may be jarred to confusion by a wrong arrangement of word or phrase.

Usually, however, and with some readers always, the first process has much of the consciousness. Here, however, with practiced readers at least, consciousness has mainly to do with the higher phrase and sentence units. The reader's mind has a complex tangle of interassociated words. Each word and class of words has its preferred associates; and when these come in the habitual sequences their perception is duly facilitated. No matter that given phrase or word group has never been seen before. Its perception will be duly facilitated, and it will be unitarily perceived if it is cast in a habitual form—if it has, *e. g.*, familiar sequences of object following preposition, or of substantive following appropriate adjective. Much of the whole matter, I believe, may be worked out from this point of view.

I have been interested in noting the part which motorization seems to have in this higher knitting together of word-units into phrase or sentence-units. The word, with myself at least, seems to be motorized as soon as singly presented, instantly

when *seen;* and this motorization seems to help hold it in consciousness while it is combining with the other words into the higher unit, the phrase, which is then itself motorized (or in reading aloud is spoken) by one unitary effort.

It is well known that in reading aloud the vocal utterance follows several words behind the eye's fixation point. It seems to me, also, that in silent reading there is a similar phrase motorization (or auditization, or both as is most usual) following behind the eye, and *after* the perception and audito-motorizing of the single words.

(This, of course, has reference to readers who motorize; and it seems difficult to find readers who do not, in a greater or less degree.) The single-word motorization does not make so much noise in consciousness as the later and reinforced utterance as part of a phrase; but is truly there, to my introspection at least.

Of the second process I can give but slight account. Most words with which we deal in reading are concepts; not representing definite single realities, but having more or less vague abstract ideas which they symbolize, and which they may or may not call to consciousness when presented.

Most of these concept words, as relational words, verbs, etc., represent abstract ideas which are very intangible; of which little clear account can be given upon the most careful introspection. Doubtless in reading there is usually a vague consciousness of the generalized experience which these words represent;—but for the most part they seem to be in the reader's consciousness as mere words; translatable in some measure at the reader's will, but the reader seldom willing. The words representing particular realities or less generalized experience more often call up these their associates.

Much of the translating seems to come not from words singly perceived, but from the perception of phrases and sentences as wholes; the words acting as "counters" until blended thus.

I have been more and more interested in the verbal side of reading. It seemed at first as though reading was dead, inane,—really *not* reading at all unless there was constant translation into the realities symbolized; but I have found various good thinkers and workers in science who seemed to be predominatingly verbalists in their reading;[1] and I am not sure but that the most of us read by far the most of our words and phrases without appreciable translation.

Such verbal readers and thinkers may be analogous to a banker who does an immense business in terms of drafts, bank-

[1] We might expect this when we recall the results of Galton's tests of the imaging power of men of science.

notes, checks, etc.,—controls all sorts of situations by them, is free to convert them into property or whatever else they represent, at any time; but would be much hampered if he actually had to do this converting very often. So such a reader carries on his reading and thinking in a kind of short-hand, uses a mental algebra, lives in a word-world, a world of symbols. He can thus be more systematic, precise, expeditious; and after all his method may not be so fundamentally different than that of the reader who habitually translates into images; for the latter is but a dealer in other symbols of the same realities; symbols which he takes comfort in thinking are more like the realities than those in which the verbalist revels.

Such use of words, however, cannot and should not come until a broad and deep basis for it has been laid in terms of experience with the realities and with the images which more nearly represent them. Words, except as they are correctly and intelligently convertible, are certainly most deceptive and dangerous symbols for the reader as for the thinker.

Practical Suggestions.

In concluding here what must remain an unfinished study, I am tempted to add a word as to the possibilities of improvement in arrangement of reading matter and in reading method.

I was led to the present study in considerable part (1) by chafing at the slowness with which we must traverse pages of books and papers, the mind appearing able to assimilate the thought much faster than the eyes can traverse the lines, or the voice the words; (2) by curiosity to know the immediate conditions of the peculiar fatigue caused by reading.

I am far from being able to conclude as to cause or cure of either condition. I am firmly convinced, however, that there is possible an arrangement of printed reading-units which will greatly lessen the work of the eyes and considerably lessen that of the mind, and which will increase the speed.

The present arrangement compels the eye to cover three or four times as much ground as is necessary to get its data. It causes unnecessary difficulty in "keeping the place," and causes a certain amount of continual distraction from the presence, in the upper and lower periphery of vision, of comparatively unrelated matter. This, however, is but a beginning of the arraignment which might be made of the present arrangement from the eye standpoint.

From the interpretation side, one of the serious objections is that the present arrangement makes "skimming" difficult and unsatisfactory. We have noticed the progressive tendency to read in larger and larger units; and this should go on until much of our reading could be done by a skimming process.

This skimming should be but an enlargement of normal reading, proceeding by a somewhat regular series of omissions and resting places, in which, however, all the matter could be taken account of in some degree. At present, however, one who attempts to "skim" down a page must proceed in a kind of hurdle-race fashion, breaking across lines of which the full content is necessarily unknown; and violating at every instant reading habits which it has taken years to form. The arrangement that is finally found to be the best for ordinary reading, will, I believe, facilitate skimming as well.

Again, improvement is to be looked for in a more systematically and logically organized subject matter. The reader's habits of word and phrase association and expectation have not been consulted in composing in the past as they will be when the psychology of style has been made a matter of common knowledge. The fact that subject matter arranged to accord with the reader's reading-habits is read in one-half the time of matter arranged contrary to these habits, suggests the immense advantage that may come from studies in this field.

It may well be that greater speed will come through a better method of reading from pages even as now printed. I await with interest the appearance of some study of reading rate among persons who have been forced for any cause to use a purely visual method. I should expect that such reading could be done at a faster rate, though possibly with disadvantage in some unlooked for direction.

I have tried various devices for increasing my own speed in reading, and have succeeded with but one, viz., to get thoroughly alive to the subject and keep *trying* to read fast. This seems to cause associative work to be done more glibly; there is more "reading inside" with fewer clues needed from the outside, and so, probably, fewer and shorter eye-fixations. In any reading we construct the thought and the words anew from inside; and if we lazily wait to *do all* this constructing after each eye-full of data is given, there is much time lost, and much room given for extraneous and distracting mind-contents. Personally, I should be grateful if I had been given speed drills in reading for thought, in my public school days.

Any adequate treatment of the matter of fatigue in reading is out of the question until the analysis of the reading-process has gone much further; especially as there is much to indicate that the fatigue is a matter which concerns the brain as much as it concerns the eye; and that the cumbrous associative word machinery may have much to do with it for most readers.

Eye-fatigue will be considerably lessened if publishers of books and papers will more constantly observe certain minimum requirements as to size and thickness of type, spacing,

quality of paper, etc., upon which investigators are in practical agreement. As to the vertical separation of the lines (in printer's phrase "the leading") and line-length, there is some disagreement; but a tendency, on the whole, toward the shorter line-lengths and a reasonable amount of "leading." It seems preferable to some writers, however, as Javal, to enlarge the type at the expense of the "leading," if necessary.[1]

But the greatest lessening of fatigue, at least of eye-fatigue, may be expected when there has been an entire reconstruction of the forms in which reading units are presented to the eye. The fossils of form perpetuated by spelling[2] and printing traditions need to be ground in the hopper of common sense, and reformed in the light of science and of that same common sense; and it may be found, upon trial, that the idols which the spelling reformers have been seeking to overthrow are not more pernicious (or perhaps more tenacious of life) than these which the printing iconoclast is soon to attack. At any rate, it is high time that we put the question whether we are doing the best that we can in our arrangements for inter-communication of thought by printed symbols.

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[1] On the subject of printing-norms, valuable suggestions will be found in articles by Javal (*Rev. Scientifique*, 1879 and 1881), Cohn (*Rev. Scientifique*, 1881), Sack, reviewed by Erisman in *Zeitschrift für Schulgesundheitspflege*, Nos. 4 and 5, 1898), Griffing and Franz (*Psych. Review*, 1896), Blasius and Ludicke (*Vierteljahrschrift f. off. Gesundheitspflege*, Bd. XIII, p. 432), Sanford (*Amer. Journal of Psych.*, I), Cattell (articles in *Mind* and in *Wundt's Studien*).

[2] Note, *e. g.*, that through the retention of the useless silent letters, the eye and the mind must deal with about one-sixth more data than is needed. See "The Spelling Reform," by Prof. F. A. March, published by U. S. Bureau of Ed., 1893.